Full Title: Consecutive days of prolonged tennis matchplay: Performance, physical, and perceptual responses in trained players.

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Abstract

Purpose: To determine how consecutive days of prolonged tennis matchplay affect performance, physiological, and perceptual responses. ***Methods:*** Seven well-trained male tennis players completed 4h tennis matches on 4 consecutive days. Pre- and post-match measures involved tennis-specific (serve speed and accuracy), physical (20m sprint, countermovement jump, shoulder rotation maximal voluntary contraction, isometric mid-thigh pull), perceptual (Training Distress Scale, soreness), and physiological (creatine kinase) responses. Activity profile was assessed by heart rate, and 3D load (au; accumulated accelerations measured by triaxial accelerometers), and rating of perceived exertion (RPE). Statistical analysis compared within and between day values. Changes (±90% confidence interval (CI)) ≥75% likely to exceed the smallest important effect size (0.2) were considered practically important. ***Results:*** 3D load reduced on days 2-4 (mean effect size±90% CI; -1.46±0.40) and effective playing time reduced on days 3-4 (-0.37±0.51) compared to day 1. RPE did not differ and total points played only declined on day 3 (-0.38±1.02). Post-match 20m sprint (0.79±0.77) and pre-match countermovement jump (-0.43±0.27) performance declined on days 2-4 compared to pre-match day 1. Although serve velocity was maintained, compromised post-match serve accuracy was evident compared to pre-match day 1 (0.52±0.58). Creatine Kinase increased each day, as did ratings of muscle soreness and fatigue. ***Conclusions:*** Players reduce external physical loads, through declines in movement, over four consecutive days of prolonged competitive tennis. This may be impacted by tactical changes and pacing strategies. Alongside this, impairments in sprinting and jumping ability, perceptual and biochemical markers of muscle damage, and reduced mood states may be a function of neuromuscular and perceptual fatigue.

Keywords: fatigue, racquet sports, activity profile

Introduction

Grand Slam and Davis Cup tennis requires professional male tennis players to compete in the best of five-set matches[1]. These matches can extend beyond 5h in duration[2,3] which can place physiological and perceptual stress on players in excess of tolerable demands[4]. However, previous literature has only described the demands of competitive tennis lasting up to 3h in duration[2,5] which is incongruent with the potential durations, and demands of matchplay on the professional tennis circuit.

The current research-derived profile of competitive tennis, with match durations up to 3h, describes point durations as between 3.0-14.9 s[6,7] and effective playing times (EPT) of approximately 16.6-26.4% of total match duration[8]. Furthermore, the internal load profile suggests mean heart rate responses range between 123-190bpm[6,9], and that players operate at 54-70% of maximal oxygen consumption (VO_2 max)[6], with ratings of perceived exertion (RPE; Borg 6-20 Scale[10]) between 11-15[8]. Physiological responses to competitive tennis matchplay have been shown to involve declined post-match muscle contractile function,[2,3,9,11] highlighted by reduced electromyography (EMG) activity[2], rate of force development (RFD)[3,9], and sprint ability[11]. Moreover, elevated creatine kinase (CK) and perceived ratings of muscle soreness[5] post-match also suggest that tennis matchplay may cause muscle damage[9]. The technical responses to tennis matchplay over an extended duration include declines in serve and groundstroke speed and accuracy[3,11], and decreased running ability[11]. However, literature profiling the physiological, perceptual, and physical responses to prolonged tennis is limited to tennis matches not encapsulating the potential duration of Grand Slam and Davis Cup competition.

Furthermore, match scheduling, participation in multiple draws (singles and doubles), and training demands mean that tennis players are often required to complete numerous training sessions and/or competitive matches on consecutive days[4]. However, limited research has examined the physiological, physical, and perceptual responses to repeated days of tennis matchplay and the findings from such evidence are conflicting[9,13,14]. One study highlights impairments to RFD and maximal voluntary contraction (MVC) of the lower extremities during a simulated 3-match tennis tournament of matches 2h in duration [9]. Whereas another study, with a similar protocol (3 competitive tennis matches each 2h duration), showed no significant reductions in lower limb performance via unchanged countermovement jump (CMJ) and isometric MVC knee torque[13]. Both suggested elevated perceptions of soreness[9,14], yet only the study by Ojala & Häkkinen (2013) reported an increase in muscle damage during the simulated tournament. In further contrast, point durations reduced in one study but remained constant in the other[9,14]. Limitations in the breadth of the available evidence base, as well as the inconsistency of the findings, highlights the need for further research. Similarly, as matches were only 2h in duration[9] and not representative of the prolonged durations of many tennis matches, the need to examine the load profiles, the performance characteristics, and physical and perceptual responses to consecutive days of prolonged competitive tennis is reinforced. Therefore, the aim of this study is to quantify the external and internal load, and the physiological, performance, and perceptual responses to consecutive days of prolonged tennis matchplay.

Methods

Participants

Seven well-trained male tennis players aged (mean±SD) 21.4±2.2years, stature 181.8±7.1cm and body mass 79.9±4.8kg, volunteered to participate in the study. Eight players commenced the study, but one withdrew after day 1. A substitute player allowed for the required even participant numbers, though data on this player was not used. Participants had played on the professional tennis circuit for 3.4±2.2years with a Australian tennis rankings ranging from 53 to 96. The nature and possible risks of the experiment were provided to participants and all gave written informed consent. The study had Institutional Human Ethics Committee approval.

Experimental Design

Participants played a 4h competitive, singles tennis match on 4 consecutive days. Physical capacity, performance, perceptual and biochemical testing were performed before and after each matchplay session. Participants were familiarised with all the testing procedures prior to the commencement of the study in two familiarisation sessions. After 24h recovery, participants undertook two days of reliability testing on all performance tests, separated by a 24h recovery period. Testing was performed in the same order and under the conditions at the same time of day. Coefficient of variation (CV%) values for each performance test are reported in the methods.

Matchplay

Participants played each competitive, singles tennis match against the same opponent determined by similar national tennis rankings. Although such a situation is unlikely in a tournament, alternating opponents on a daily basis is likely to affect the tactical approach and physical load of respective matches. Accordingly, to ensure competitiveness and to elucidate the effect of repeated days matchplay *per se*, we opted for players to remain as the same competitive pair throughout the study. We recognise however, that this does not explicitly represent a tournament setting. Scoring and rest periods complied with the rules of the International Tennis Federation[1] and participants were instructed to play an unlimited number of sets in the 4h period. Matches were played on indoor Plexicushion® courts using Wilson Tour tennis balls, which were changed after 2h of matchplay. The air temperature and humidity were (mean±SD) 12.4±1.7°C and 65.8±5.3% respectively.

Testing Protocol Overview

During the 4 days of matchplay, all measurements were performed at standardised times and in specific order (Figure 1). On waking, participants provided a mid-stream urine sample to measure Urine Specific Gravity (USG). A breakfast of a standardised carbohydrate (CHO) content at $2.0 g \cdot kg^{-1}$ body mass was provided. On arrival at the testing facility, players completed a Multi-Component Training Distress Scale (MTDS) questionnaire to measure signs of staleness and overtraining[15], and provided a muscle soreness rating (Likert 1-10 scale[16]). Body mass was recorded on calibrated weigh scales (MS3200, Charder Electronic Co.Ltd, Taiwan), and a venous blood sample was obtained. Participants then performed a standardised warm-up (Figure 1). Following the warm-up, subjects performed physical capacity and performance testing in the following order: 1) 20m sprint, 2) serve velocity and accuracy, 3) CMJ, 4) internal (IR) and external rotation (ER) MVC of the dominant shoulder, and 5) an isometric mid-thigh pull (IMTP). Once matchplay commenced (T_0), players competed continuously for 240min with RPE (Borg CR10 Scale[6]) recorded every 30min and again 30min post-match (T_{270}). Water and standardised CHO at 2.5g$\cdot$kg^{-1} body mass were provided throughout the match for *ad libitum* consumption. Immediately post-match (T_{240}), the physical capacity and performance tests were repeated followed by a standardised 15min warm-down. Thirty min post-match (T_{270}), the MTDS, and muscle soreness scale were again completed, body mass was recorded, a venous blood sample was obtained, and a standardised CHO snack of 1.0g$\cdot$kg^{-1} body mass provided. Throughout the study players refrained from consuming caffeine and alcohol, and were required to maintain a food diary. Players were placed in accommodation throughout the data collection period to ensure standardised sleeping arrangements.

*** Insert Figure 1 here ***

The Multi-Component Training Distress Scale is a 22-item self-reporting monitoring tool of training overload[15]. Measures of depressed mood, perceived vigour, physical symptoms, sleep disturbance, perceived stress, and general fatigue in the previous 24h[15] are recorded on a 10-point Likert scale[16].

External and Internal Load. Heart rate (HR) was continuously recorded throughout matchplay (Memory Belt, Suunto Oy, Vantaa, Finland) with data downloaded to specific software (Moveslink, Suunto Oy, Vantaa, Finland) to obtain mean HR values. 3D load, being the sum of the squares of instantaneous accelerations in the mediolateral, anteroposterior, and vertical planes[17] (load) was measured using accelerometers (MinimaxX, Catapult Sports, Victoria, Australia). The accelerometers sampled at 100Hz, and were worn by participants in custom-made pouches that positioned the device between the scapulae. Data were downloaded (Sprint 5.1.0, Catapult Sports, Victoria, Australia) to obtain total load and the relative contribution of each individual vector (load accumulated in each plane individually as a percentage of total 3D load[17]). Rest breaks including changing ends and at the completion of sets, were removed from the data to ensure the load values only included actual matchplay. Further, all matches were filmed with a video camera (DSR-PDX10P, Sony, Japan) positioned 8m behind the baseline and 8m above each court. Coding of the footage was performed by a trained analyst (CV<3%) using customised software (SportsCode Elite, Sportstec, Australia) to determine error and winner counts, first serve percentages (FS%), and EPT.

20 metre Sprint. A 20m sprint (including 5m and 10m splits) was conducted on a neighbouring indoor Plexicushion® tennis court with electronic timing gates (SpeedLight TT, Swift Performance Equipment, Queensland, Australia). Participants were required to use a stationary start position with front toe placed on the start line[18]. As players were familiarised with all the tests, only one trial was performed with each split being recorded (CV≤2.2%).

Serve Speed and Accuracy Test. To determine maximal serve speed and accuracy, participants were instructed to perform 6 maximal serves aiming to land the serve within 1m of the centre-service line. This was classified as an accurate serve. Right-handed participants served from the deuce side of the baseline with left-handed participants served from the advantage side. Players were required to achieve 3 accurate serves, with additional serves permitted until this was achieved. A hand-held radar gun (Stalker Sport 2, Stalker, Texas, USA) was positioned 2m directly behind the player's ball toss position, aimed in the direction of the ball to record serve velocity (1.9% CV). The fastest accurate serve, and the number of serves required to obtain 3 accurate serves were retained.

Countermovement Jump (CMJ) was performed on a portable force plate (400s, Fitness Technology, Adelaide, Australia) sampling at 500Hz. Participants performed a jump for maximum height, with self-selected level of countermovement, whilst hands remained on hips[19]. Absolute mean and peak force (N), power (W), and jump height (cm) was calculated (CV≤3.1%) in manufacturer software (Ballistic Measurement System, Fitness Technology, Adelaide, Australia).

Isometric Maximal Voluntary Contraction of the Dominant Shoulder IR (10.8% CV) and ER (9.5% CV) were measured using a hand-held dynamometer (Power Track II, JTech, Utah, USA). Testing was undertaken in accordance with that performed by previous research[20]. Three trials of both IR and ER were performed with the best result (kg) being retained.

Isometric Mid-Thigh Pull (IMTP) was performed as a test of lower body maximum strength (4.2% CV) using a force plate (400s, Fitness Technology, Adelaide, Australia) following a previously described standardised protocol[19]. One trial was performed with maximal force (N) calculated (Ballistic Measurement System, Fitness Technology, Adelaide, Australia).

Blood Sampling. Ten-millilitre venous blood samples were drawn from an anticubital vein into serum separator tubes (SST tubes, BD Vacutainer, North Ryde, NSW, Australia) using standard venipuncture techniques. The samples were allowed to clot at room temperature for 15min before centrifugation (10min at 4000 rpm). Samples were stored at -80°C prior to their analysis. Creatine kinase concentration was determined using an enzymatic method and bichromatic rate technique (CV≤1.4%; Cobas, Roche Diagnostics, Mannheim, Germany).

Statistical Analysis

Customised Microsoft Excel spreadsheets[21] were used to analyse the within and between-day changes. Values were log transformed to reduce bias due to non-uniformity of error. The magnitude of the difference was calculated using the Effect Size Statistic ± 90% CI[21]. A difference was considered likely positive/negative if there was a ≥75% chance of exceeding the smallest practically important effect, set as a standardised effect threshold of 0.2. Changes of smaller magnitude were classified as trivial, and where the 90% CI overlapped substantially positive and negative values, the difference was considered unclear. The Result values are presented as mean±SD and differences as effect size ± 90% CI with a qualitative descriptor to represent the likelihood of exceeding the 0.2 threshold.

Results

Matchplay Performance

Mean (±SD) match notation variables are presented in Table 1; with EPT likely lower on days 3 (effect size±90% CI, qualitative descriptor; -0.33±0.72, 76% likely), and 4 (-0.41±0.29, 93% likely) compared to day 1. 3D load relative to EPT was likely reduced on day-4 (-1.56±1.43, 94% likely) compared to day-1, with unclear changes on day 2-3. Serve velocity ($km \cdot h^{-1}$) likely increased by 76-80% post-match on days 2 (0.51±0.79), 3 (0.63±60.92), and 4 (0.54±0.77) compared pre-match on day-1 (Table 2). Serve accuracy declined on days 2-3 compared to the same time-point on day 1 (Table 2).

*** Insert Table 1 and 2 here ***

External Load

Total 3D load reduced on days 2 (-0.71±0.48 96% likely), 3 (-1.72±0.26, 100% likely), and 4 (-1.96±0.44 100% likely) compared to day 1 (Figure 2a). Total 3D load during the second 2h of matchplay was lower compared to the first 2h of matchplay within and between matches on days 2-4 (Figure 2b). Individual vector percentage contributions changed between days (Figure 2c); however, the only within day change occurred in the mediolateral vector, reducing in the second 2h of play on day 1 (-0.34±0.29 81% likely).

*** Insert Figure 2a-c here ***

Internal Load

Mean±SD RPE for days 1-4 were 4.6±1.9, 4.3±2.1, 4.1±1.9, and 4.1±2.2 respectively. These values did not change between days. Mean±SD HR for each match was 132±13, 122±14, 122±13, and 124±8 respectively. Mean HR was 92-100% likely lower on days 2 (-0.61±0.51), 3 (-0.77±0.44), and 4 (-0.81±0.17) compared to day 1.

Sprint Speed

Mean (±SD) sprint times pre and post-matchplay are presented in Figure 3. Five-metre sprint times were 81-100% likely slower pre days 2 (0.59±0.80), 3 (1.21±0.52), and 4 (1.89±1.41) compared to pre-day 1. Twenty-metre sprint times improved pre to post-match on days 3 (-0.53±0.54 86% likely) and 4 (-0.27±0.28 75% likely).

*** Insert Figure 3 here ***

Countermovement Jump and Isometric Mid-Thigh Pull

Table 3 presents the mean (±SD) CMJ and IMTP values before and after matchplay. CMJ height (cm) was reduced post-match on days 1 (-0.63±0.72 86% likely) and 2 (-0.51±0.45, 88% likely) compared to their respective pre-match measures. IMTP peak force (N) was 76-90% likely lower pre and post-match on days 2 (-0.49±0.4 and -

0.57±0.49 respectively) and 3 (-0.34±0.43 and -0.72±0.91 respectively) compared to pre-match day 1.

*** Insert Table 3 here ***

Dominant Shoulder Maximal Voluntary Contraction

Mean (±SD) shoulder ER and IR MVC values are presented in Table 3. Shoulder IR MVC was likely reduced pre to post-match on all days. Shoulder ER MVC was also likely reduced post-match on days 2 (-1.40±0.76, 99% likely), 3 (-0.38±60.47, 75% likely), and 4 (-0.56±0.52, 89% likely) compared to pre-match day 1.

Biochemical and Perceptual Muscle Damage

Mean (±SD) creatine kinase and muscle soreness rating values are represented in Figure 4. Creatine kinase was substantially elevated at all time-point comparisons. Muscle soreness ratings were 100% likely increased at pre and post-match measures on days 2 (2.47±0.76, 4.11±0.69 respectively), 3 (2.99±0.41, 3.96±0.70 respectively), and 4 (2.65±0.51, 4.14±0.63 respectively) in comparison to pre-match day 1.

***** Insert Figure 4 here *****

Multi-Component Training Distress Scale Responses

Mean (±SD) MTDS scores are presented in Table 4. Mood ratings were substantially higher (suggesting a decline in mood-state) post-match on days 1-3 compared to pre-match ratings. Fatigue ratings were elevated at all time points compared to pre day 1, as well pre-to-post measures within days 1 (1.30±0.61, 99% likely) and 2 (0.48±0.58, 81% likely).

***** Insert Table 4 here *****

Hydration Status and Body Mass

In comparison to day 1, USG values were 79-88% likely higher on days 2 (0.49±0.60%), 3 (0.47±0.61%), and 4 (0.52±0.49%). Additionally, body mass showed 94-97% likely trivial changes post-match on days 3 (-0.08±0.13%) and 4 (-0.04±0.13%).

Discussion

The aim of the current study was to assess the performance, physiological, and perceptual response to repeated days of prolonged tennis matchplay. Such responses involved impairments to movement, sprinting and jumping ability alongside increased muscle damage markers, and poorer mood state, suggesting elements of neuromuscular and perceptual fatigue. Player perceptions of effort also remained constant over the 4 days inferring the potential of pacing and/or tactical modifications given the noted reduced movement profile. More specifically, a key finding was that 3D load showed substantial decline on days 2-4 compared to day 1 (Figure 2a). Complementing this, EPT reduced on days 3 and 4 (Table 1). Yet, the decline in 3D load on day 4, relative to the decline in EPT on the same day, was substantially greater, suggesting that players actually performed less movement during matchplay rather than it being an artefact of less playing time. This reduction may be due to the interactions of tactical changes[9] and/or both within-match acute and between-match residual fatigue mechanisms[2,3]. Additionally, the reduction in movement occurs in the context of a stable RPE. This suggests the potential employment of a pacing strategy, as it would otherwise seem plausible for perceptual effort to increase in an effort to maintain internal and external output under physiological fatigue[4].

Notational matchplay characteristics did not likely change over the 4 days, except for reductions in unforced errors and forced errors on days 3 and 4 respectively (Table 1). Previous research suggests that fatigued players alter their tactical approach to hit more achievable shots, thus resulting in reduced error rates [9,11]. Such tactical changes are borne out in the unchanged winner count observed here, as generally an increase in winners correlates with an increase in errors[11]. This is due to the greater precision and risk required to successfully hit unreturnable shots[11]. Alternatively, changes to stroke intention (reduced errors, and winner attempts) may have been employed as a pacing strategy to limit the growing effects of physiological or perceptual fatigue[28], as opposed to being a direct product of fatigue. Although the causal link remains unclear, it seems plausible that the interplay between both fatigue and pacing was present.

Further to changes in point outcomes, first serve percentage (within matchplay) only increased day 2 (Table 1). Conversely, there were reductions in serve accuracy (in the serve speed and accuracy test; Table 2) over the 4-day period. This paradox can be explained by the difference in specific demands between tasks. Within-match serves are classified as ‘in’ if landed in the service box, whereas the serve speed and accuracy test demands maximal service efforts to a precise target area (within 1m of the centre-service line). Fitt’s Law describes a trade-off between speed and accuracy[26] and subsequently it can be deduced that accuracy was jeopardised in the serve test due to the precision and speed demanded. Moreover, declines in shoulder ER and IR MVC over the 4 days (Table 3), which have been shown to be important in the kinematics and subsequent velocities of overarm skills[25], may imply an adjustment in serve kinematics to maintain serve velocities. Subsequently, it might be proffered that tasks demanding greater precision are more greatly affected by fatigue[26,27]

The decline in movement on days 2-4 may also be due to compromised neuromuscular status[2,3], although the precise mechanisms underpinning these changes are unclear. It appears likely that neuromuscular fatigue (NMF) of central and/or peripheral origin is at least partly implicated[2,3]. This is supported by reductions in CMJ height and IMTP peak force at the majority of time point comparisons (Table 3). Additionally, increases in CK and ratings of muscle soreness within and between matches may indicate muscle damage (Figure 4). It can be speculated that muscle damage sustained on day 1, and potentially exacerbated on subsequent days (as evidenced by changes in CK and perceptual measures of muscle soreness), has impacted the integrity of contractile elements and influenced high velocity movements on following days[22]. The decline in 10m and 20m sprint ability (Figure 3), and reductions in CMJ height and mean power on all days compared to pre-match day 1 (Table 3) support this contention. Further, CMJ peak power and IMTP peak force showed reductions on days 2 and 3 compared to day 1 (Table 3). Conversely, previous studies observing physical responses to consecutive days of matchplay found no reductions in CMJ ability and negligible reductions in 5m-sprint speed[9,13,14]. This suggests that movements characterised by high velocity SSC contractions, as well as high force output, may only be sensitive to the impact of consecutive days of tennis matchplay when matches are greater than 2h duration[9,23].

Changes in individual vector contributions to 3D load, namely reductions in anteroposterior and mediolateral contributions on days 2-3, also suggest modifications to specific movement patterns (Figure 2c). It is possible that these changes represent a reduction in rapid forward-backward and lateral movements, which may be related to fatigue and/or tactical changes. Alterations to players' movement strategies may have also eventuated from their perceptions of fatigue. For example, the unchanged RPE values imply that players had the same perceived effort even with the performance of less movement and shorter EPT. This is supported by reductions in mean HR on the same days suggesting a reduction in intensity due to a decline in work volume. Additionally, players rated their level of general fatigue post-match on days 2-4 greater than pre and post-match day 1 (Table 4). These responses suggest that players were sensitive to the effects of the prolonged competition after 2 days of matchplay and their state of fatigue did not improve thereafter. Adverse ratings of mood, vigour, and stress post-match on days 2-4 compared to pre day 1 (Table 4) reinforces this trend and further highlight that players presented symptoms of physical and mental distress. It then seems plausible that elements of perceptual fatigue, reduced motivation[28], and/or pacing[28] may have contributed to the decline and changes in external loads on days 2-4.

It is important to recognise potential limitations of this study, not least the small sample size. Moreover, players were not Grand Slam or Davis Cup competitors and therefore were less accustomed to competing for such extended periods, therein potentially limiting the generalizability of the results. Additionally, as the daily opponents did not vary, players may have become accustomed to each other's game styles and patterns therein potentially affecting the tactical changes reported. A further limitation to the study is the possible hypohydration[30] of the subjects. Mean USG values were above 1.02[30] at waking on days 2-4 and trivial body mass changes were present on days 3-4. This may, in part, be displayed in the reduction in contraction velocity, player movement, and subsequent match performance[30]. Whilst an amplified physiological load was potentially present due to hydration status, it is unlikely to be the sole contributing factor to performance decrements.

Practical Applications

The results of this study demonstrate that overall movement and performance of high velocity tasks are suppressed by repeated days of prolonged tennis matchplay. This suggests that physical-performance and tennis coaches should focus on tailored repeat-effort high-intensity training, and specific strength-training to help defend against reductions in SSC based movements[9]. Thus, assisting athletes in meeting the demands of tournament tennis. Psychological strategies to overcome stress, and improve mood-state and motivation in conjunction with physical recovery modalities should be utilised to combat the potential impairments to performance. Further research examining the relationship between physical fitness capacities and the fatigue responses to consecutive days of prolonged tennis matchplay may provide insight into how fatigue decrements can be minimised.

Conclusion

Four-hours of competitive tennis matchplay repeated over consecutive days resulted in a reduction in total movement and performance of explosive tasks. Decrements to lower limb force and power production inferred from sprinting and jumping impairments allude to some element of neuromuscular fatigue. Moreover, the maintenance in perceived effort, reductions in mood states, increases in ratings of fatigue and soreness, as well as elevated muscle damage markers, suggest complex interactions between perceptual and physiological fatigue. In addition, pacing strategies to reduce external load in an attempt to maintain RPE may also play a role in the declines displayed during prolonged tennis matchplay over repeated days.

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Figure Captions

Figure 2a-c: 3D Load values, and individual vector contributions (mean±SD, n=7) at T_0-T_{120} = First 2 hours of matchplay; T_{120}-T_{240} = Second 2 hours of matchplay. † = ≥75% likely negative change compared to T_{240} day 1; ø = ≥75% likely negative change compared to T_0 day 1; ‡ = ≥75% likely positive change compared to T_{240} day 1; * = ≥75% likely negative change between T_0 and T_{240} on the same day.

Figure 3: Sprint times (mean±SD, n=7) at T_0 = Immediately prior to matchplay; T_{240} = Immediately post matchplay. § = ≥75% likely positive change between T_0 and T_{240} on the same day; * = ≥75% likely negative change between T_0 and T_{240} on the same day; # = ≥75% likely positive change compared to T_0 day 1; ‡ = ≥75% likely positive change compared to T_{240} day 1.

Figure 4: Creatine Kinase and Muscle Soreness Ratings (mean±SD, n=7) at T_{-30} = 30 minutes prior to matchplay; T_{270} = 30 minutes post matchplay. § = ≥75% likely positive change between T_0 and T_{240} on the same day; * = ≥75% likely negative change between T_0 and T_{240} on the same day; # = ≥75% likely positive change compared to T_0 day 1; ø = ≥75% likely negative change compared to T_0 day 1; ‡ = ≥75% likely positive change compared to T_{240} day 1; † = ≥75% likely negative change compared to T_{240} day 1.

Table 1 Notational Match Analysis Variables

	Day 1	Day 2	Day 3	Day 4
Effective Playing Time (min)	55.3 ± 8.5	52.7 ± 10.4	49.5 ± 5.0 †	52.5 ± 4.9 †
Total Points Played	329 ± 48	340 ± 35	301 ± 40 †	325 ± 81
Average Point Duration (sec)	10.1 ± 0.1	9.3 ± 1.0 †	9.9 ± 0.3	9.9 ± 1.6

Total Strokes	727 ± 125	692 ± 155	662 ± 55 †	690 ± 42
Unforced Errors	67 ± 15	65 ± 24	57 ± 14 †	66 ± 26
Forced Errors	47 ± 10	50 ± 7	49 ± 12	42 ± 10 †
Winners	48 ± 21	51 ± 12	44 ± 13	49 ± 16
First Serve Percentage (%)	65 ± 5	68 ± 3 ‡	67 ± 3	67 ± 4

Notational match analysis variables (mean±SD, n=7) at T_0 = Immediately prior to matchplay; T_{240} = Immediately post matchplay. † = ≥75% likely negative change compared to T_{240} day 1; ‡ = ≥75% likely positive change compared to T_{240} day 1

Table 2 Serve Velocity and Accuracy Test Measures

Time Point	Velocity (km.h^{-1})	Accuracy (au)
Day 1 T_0	175 (12)	6 (2)
Day 1 T_{240}	169 (8)	6 (1)
Day 2 T_0	171 (13)	7 (2) ‡
Day 2 T_{240}	174 (11)	8 (3) ‡#
Day 3 T_0	168 (11) †	8 (3) ‡
Day 3 T_{240}	176 (14) §	8 (3) ‡#
Day 4 T_0	172 (8)	6 (2)
Day 4 T_{240}	175 (9)	6 (2)

Serve velocity and accuracy (mean±SD, n=7) at T_0 = Immediately prior to matchplay; T_{240} = Immediately post matchplay. † = ≥75% likely negative change compared to T_{240} day 1; ‡ = ≥75% likely positive change compared to T_{240} day 1; § = ≥75% likely positive change between T_0 and T_{240} on the same day; # = ≥75% likely positive change compared to T_0 day 1.

Table 3 Countermovement Jump, Isometric Mid-Thigh Pull, and Shoulder External and Internal Rotation Maximal Voluntary Contraction

	Day 1 T_0	Day 1 T_{240}	Day 2 T_0	Day 2 T_{240}	Day 3 T_0	Day 3 T_{240}	Day 4 T_0	Day 4 T_{240}
CMJ Height (cm)	36.5 ± 6.5	32.7 ± 7.6 *	33.3 ± 6.3 Ø	30.3 ± 6.8 *	33.0 ± 5.4 Ø	30.3 ± 7.0 Ø	33.7 ± 5.3 Ø	32.3 ± 5.3 Ø
CMJ Peak Force (N)	1807 ± 112	1845 ± 220	1818 ± 162	1828 ± 200	1822 ± 163	1838 ± 212	1833 ± 164	1842 ± 180 ◊
CMJ Peak Power (W)	4193 ± 593	4056 ± 485	4040 ± 454	3819 ± 349*	4086 ± 541	3905 ± 489 Ø	4063 ± 471	4060 ± 422
CMJ Mean Force (N)	792 ± 47	782 ± 51	787 ± 53 ^	792 ± 58 ◊^	788 ± 50 ^	791 ± 48 ◊	792 ± 54 ^	793 ± 54 ◊^
CMJ Mean Power (W)	1136 ± 84	1041 ± 92 *	1080 ± 70 Ø	1008 ± 56 *	1084 ± 81 Ø	1047 ± 117 Ø	1080 ± 49 Ø	1071 ± 62 Ø
IMTP Peak Force (N)	2007 ± 203	2019 ± 462	1892 ± 191 Ø	1883 ± 159◊ Ø	1933 ± 246 Ø	1859 ± 242 Ø	1958 ± 291	1965 ± 276 ◊•
MVC Shoulder ER (kg)	16.9 ± 1.7	15.8 ± 0.8 *	15.0 ± 1.1 Ø	14.1 ±1.6 *†Ø	16.1 ± 1.0 Ø	16.1 ± 2.3 Ø	17.7 ± 2.1	15.7 ± 1.9 * Ø
MVC Shoulder IR (kg)	20.7 ± 3.3	18.9 ± 2.9 *	21.0 ± 1.4	18.4 ± 3.8 *Ø	20.6 ± 1.7	19.6 ± 2.2 *	22.1 ± 3.5 #	20.5 ± 2.9 *‡

Countermovement Jump, Isometric Mid-Thigh Pull, Shoulder External and Internal Rotation Maximal Voluntary Contraction (mean±SD, n=7) at T_0 = Immediately prior to matchplay; T_{240} = Immediately post matchplay. * = ≥75% likely negative change between T_0 and T_{240} on the same day; ◊ = ≥75% likely trivial change between T_0 and T_{240} on the same day; ø = ≥75% likely negative change compared to T_0 day 1; ‡ = ≥75% likely positive change compared to T_{240} day 1; † = ≥75% likely negative change compared to T_{240} day 1; ^ = ≥75% likely trivial change compared to T_0 day 1; • = ≥75% Likely trivial change compared to T_{240} day 1.

Table 4 Multi-Component Training Distress Scale (Main & Grove, 2009) Variables Immediately Pre and Post Matchplay

Time Point	Mood	Vigour	Physical Symptoms	Sleep Disturbances	Stress	Fatigue
Day 1 T_0	2 (3)	8 (1)	5 (2)	4 (2)	3 (4)	3 (1)
Day 1 T_{240}	8 (5) §	8 (4)	9 (3) §	2 (2)	5 (4) §	8 (3) §
Day 2 T_0	6 (4)	6 (2) †	9 (3) ‡	2 (2) †	4 (4)	7 (3) ‡
Day 2 T_{240}	8 (5) §#	5 (4) † ø	9 (3) #	2 (2) ø	6 (4) §#	9 (3) §#
Day 3 T_0	5 (4) ‡	5 (1) †	9 (3) ‡	3 (2) †	4 (4)	8 (2) ‡
Day 3 T_{240}	7 (5) §#	6 (4) † ø	9 (3) #	3 (3)	5 (4) #	9 (3) #
Day 4 T_0	6 (5) ‡	5 (2) †	8 (3) ‡	4 (3)	5 (5)	9 (3) ‡
Day 4 T_{240}	8 (6) #	5 (4) † ø	10 (2) §#	4 (3)	5 (4) #	9 (3) #

Multi-Component Training Distress Scale values (mean±SD, n=7) at T_0 = Immediately prior to matchplay; T_{240} = Immediately post matchplay. § = ≥75% likely positive change between T_0 and T_{240} on the same day; # = ≥75% likely positive change compared to T_0 day 1; ø = ≥75% likely negative change compared to T_0 day 1; † = ≥75% likely negative change compared to T_{240} day 1; ‡ = ≥75% likely positive change compared to T_{240} day 1.

Figure 1 Timeline of Measurements Performed on each Matchplay Day

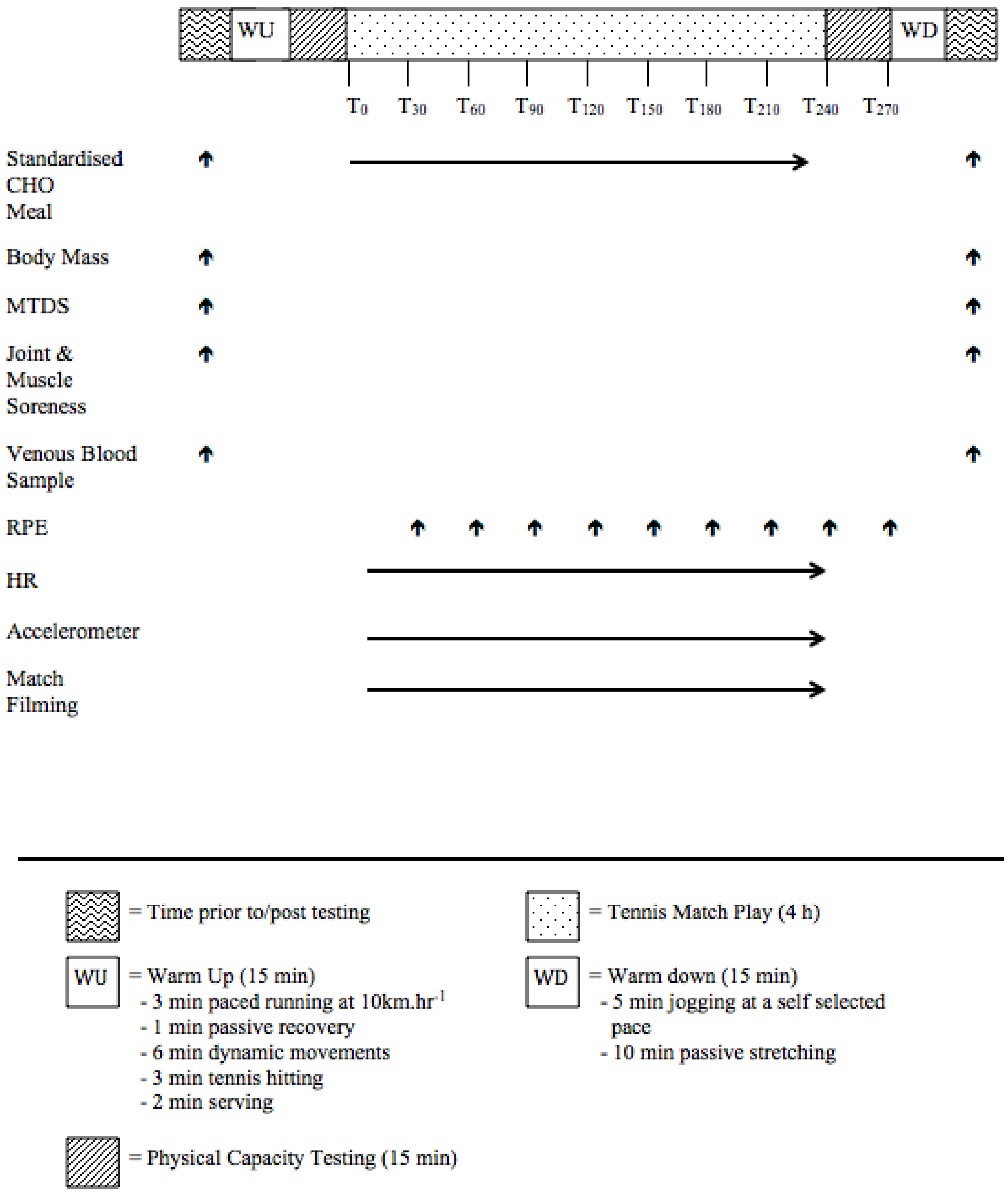
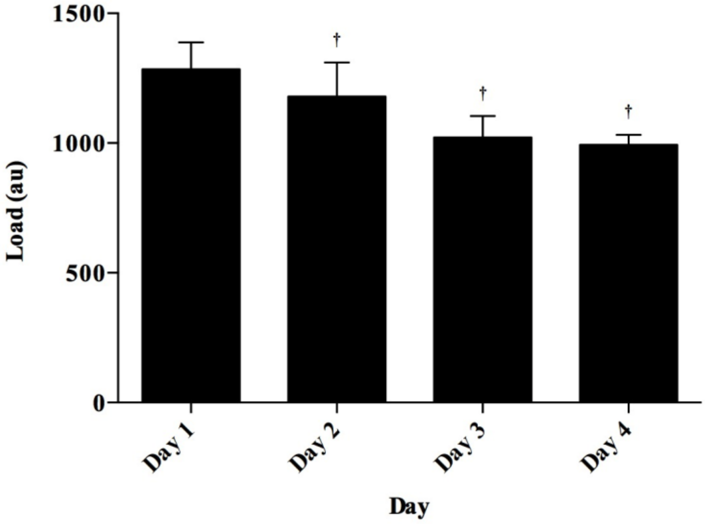
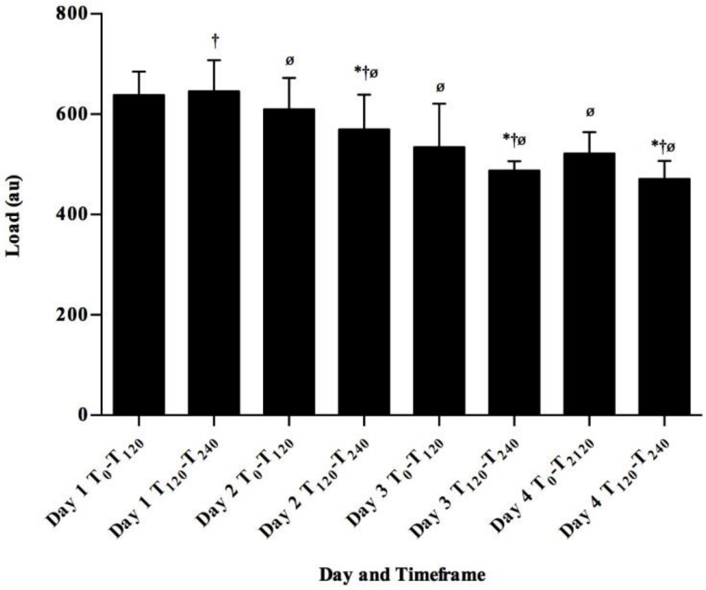


Figure 2a-c Total day 3D load (a), 2 hour breakdown of 3D load (b), Individual Contribution of Mediolateral, Anteroposterior and Vertical Vectors (c) within and between Matchplay Days

a)



b)



c)

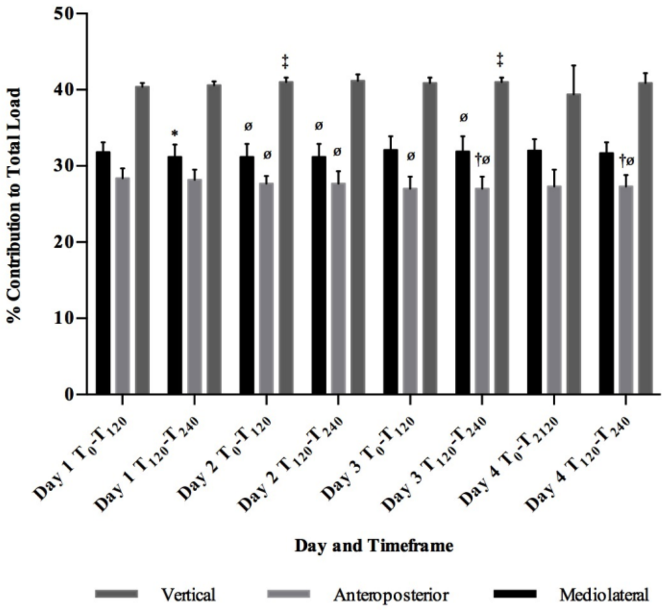


Figure 3 Sprint Times at T_0 and T_{240} on Each Matchplay Day

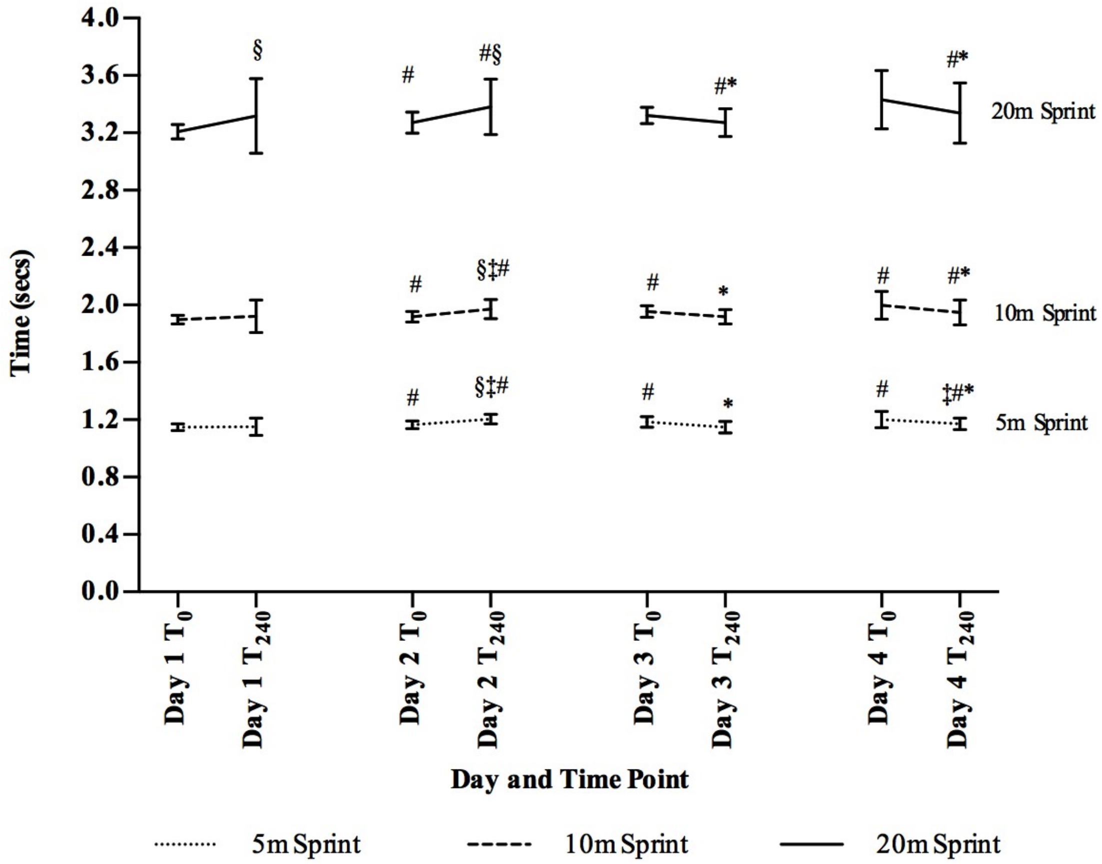


Figure 4 Creatine Kinase and Muscle Soreness Ratings Pre and Post Matchplay